

SCDMS Cooldown Estimate for 300 K to 7 K

What is an acceptable time?

Cool down assumptions

- 2607 kg of Cu for LN thru MC layers
- 1903 kg of Cu for LHe thru MC layers
- 164 kg of poly in all calculations
- Specific heats curve fit and integrated for each step
- Cu and poly at same temperature at each step

300 K to 77 K for LN-MC layers

- Use 1000 W LN2 heat exchanger linked to both LN and LHe layers, IVC filled with GHe
- Using only latent heat of LN2
 - 3 days
 - 1500 liters of LN2, 21 liters per hour
- Link from LN2 heat exchanger to both layers must be efficient when full of liquid and insulating when empty

300 K to 77 K for LN-MC layers

- Vericold is working on a cooldown LN2 heat exchanger that may suit SCDMS needs, find out more Jan. 25th
- If you assume a conservative 6 W/in² pool boiling heat flux the area is then 167 in² or a bit more than 1 ft².
- LN2 heat exchanger could be a bath in the fridge or a tube brazed to the LN & LHe layers in the fridge

300 K to 77 K for LN-MC layers

- Cryogen free cool down is difficult to implement
- Two 2 stage cryocoolers
 - 60 W from 1st stage of each cryocooler = 120 W
 - Heat load at LN layer will be on the order of 60 W when 77 K is reached
 - So cool down would be between 23 (120 W) and 45 days (60 W)....clearly too long
- 300 W from a large single stage cryocooler
 - Cooldown would be 9 days @ 300 W
 - Still need the two 2 stage cryocoolers for steady state operation so now up to 3 cryocoolers
 - Problem is how to thermally link a cryocooler to both the LN and LHe layers and then disconnect to avoid a large parasitic thermal load

77 K to 7 K for LHe-MC layers

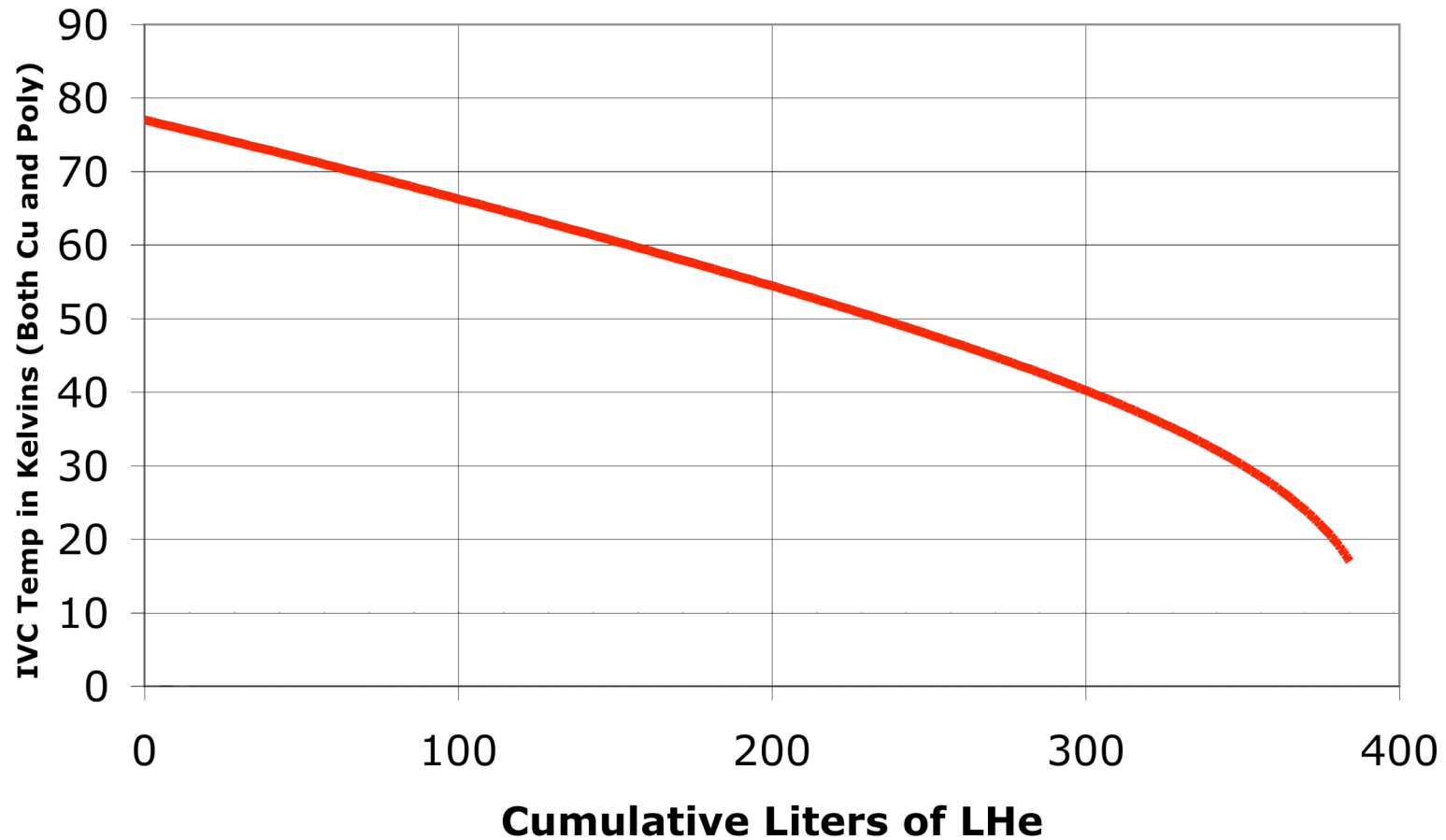
- **Option 1:** Cryogen free - Use two 2 stage cryocoolers
 - 2nd stages linked to LHe layer, GHe fills IVC
 - 77K to 17 K, estimate each cryocooler provides 9 W, takes 9 days. Cryocooler 2nd stage performance not measured above 17 K and *unknown*. Need to test.
 - 17 K to 7 K, estimate each cryocooler provides 7.5 W, takes 0.12 days (very little Cp to remove)
 - Ignoring joint resistances which will increase the times somewhat at the colder temperatures

77 K to 7 K for LHe-MC layers

- **Option 2:** Use some LHe in addition to the cryocoolers to speed up cool down of IVC
 - Liquid helium heat exchanger linked to IVC and GHe fills IVC
 - 100 W LHe heat exchanger takes 1.5 days for 77 K to 7 K and 400 liters vs. 9 days with two cryocoolers
 - The cryocoolers then pull the mass down from 7 K
 - Its possible LN2 could be in the LHe heat exchanger during the 300 K to 77 K part of the cooldown.
 - Still need to physically size LHe heat exchanger, more complicated due to need to utilize all the superheat

77 K to 7 K for LHe-MC layers

Cooling IVC from 77 K to 10 K using LHe from dewars



Terry Tope 1.11.08

Summary for 300 K to 7 K

Method	Time
LN2 and LHe HX	4.5 days
LN2 HX and 2 cryocoolers	12 days
2 cryocoolers	$32 < x < 54$ days
3 cryocoolers	18 days

Thermal Model Update

- Fixed typo in ANSYS carbon thermal conductivity function
- Now SCDMS detector area heat flows > than Soudan
- ANSYS LHe heat load still looks incorrect
- Working on Blas's Matlab code to compare to ANSYS SCDMS
- Will break out heat flows path by path

1st run of updated MATLAB for SCDMS

Layer	Heat flow at fridge connection	Can Temp K
LN	56 W	122
LHe	3.6 W	12.7
ST	38,655 μ W	3.13
CP	561 μ W	0.438
MC	6.2 μ W	0.066